Variable Renewable Energy Sources

Innovations in Life Cycle Management Toward Climate Friendly Lifetstyles

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Necessary Reduction of Greenhouse Gas Emissions

Observed and Modelled Global Temperature Change

Paris Target

Source: IPCC 2018
The FOUR Factors Influencing Greenhouse Gas Emissions

Future Energy System

Lifestyle

\[ tCO_{2eq} = \frac{tCO2eq}{GJ_{energy}} \times \frac{GJ_{energy}}{Service} \times \frac{Service}{P} \times P \]

1) Emission factor (e.g. renewable energy)
2) Energy-efficiency
3) services per person
4) number of people

Source: based on “IPAT-Formel” of A. & P. Ehrlich
Characteristics of Future Energy Systems

Renewable Energy Sources:
- PV: high variable
- Wind: medium variable
- Hydro: low variable
- Biomass: storage
Characteristics of Lifestyles

National GHG emissions per capita become obsolete in a global economy!
There is international consensus that the environmental effects of products and services can only be analyzed on the basis of Life Cycle Assessment (LCA), which includes the production, operation, and the end of life treatment.
GHG Emissions of Austrian Lifestyle

Example
Carbon Footprint of Food Basket

10 €

= 20 vehicle-km

4 kg CO₂-eq.

Consumption Based GHG Emissions of the Austrians

13 - 15 t CO₂-eq/(cap * a)
50% abroad + 50% Austria
Cumulating Effects over Lifetime

Cumulated environmental effects
- e.g. GHG-emissions

Possible environmental effects:
- Climate change (kg CO₂ eq)
- Ionizing radiations (kg U235 eq)
- Resource depletion water (kg water eq)
- Mineral, fossil & renewable resource depletion (kt, GJ)
- Land use (kg C deficit; ha)
- Photochemical ozone formation (kg NMVOC eq)
- Terrestrial eutrophication (mol cN eq)
- Freshwater eutrophication (kg P eq)
- Marine eutrophication (kg N eq)
- Ozone depletion (kg CFC-11 eq)
- Human toxicity - cancer effect (CTUh)
- Human toxicity - non cancer effect (CTUh)
- Acidification (mol H+ eq)
- Particulate matter (kg PM2.5 eq)
- Freshwater Ecotoxicity (CTUe)
(Variable) Renewable Energy Sources

Innovations in Life Cycle Management

- **Variable power supply** by PV and wind: inclusion of storage systems to meet demand
- **Bioenergy**: time effects of CO$_2$-fixation – C-storage – CO$_2$-emissions
- **End of Life management**: Reuse and recycling of materials/components e.g. rare earth metals e.g. Ni, Co
- Strategies to reach and assure **Climate neutrality** of renewable energy sources in whole life cycle to reach Paris targets
Definition

- A product/service is „climate neutral“, if in the total lifecycle no greenhouse gas emissions (in CO₂-eq.: CO₂, CH₄, N₂O, SF₆, FCKW, etc.) occur.
- ..and/or the remaining greenhouse gas emissions are compensated by activities/measures in other areas permanently.
- …in which the timeline of greenhouse gas emissions must be taken into account (timing of GHG emissions).

Ways for Realization

- Climate friendly consumption of products/services of high quality.
- Increasing material & energy efficiency.
- Substitution of fossil by renewable energy.
- Reduction of direct agricultural CH₄- & N₂O emissions.
- Permanent CO₂-storage
  - CCS: Carbon Capture and Storage.
  - CCU: Carbon Capture and Utilization.
  - Additional C-storage in biomass, soils and products: guarantee durability!
Climate Friendly Lifestyles

The „Paris Lifestyle“ is an innovative and satisfying „Low Carbon Lifestyle“ characterized by having very low greenhouse gas emissions contributing to the Paris Agreement of limiting global warming to below 2°C. The Paris Lifestyle creates new economic opportunities and challenges by stimulating an increasing demand for low/zero Carbon products and services.